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Automatic Rail Car Identification and Reports

Several years ago, a group of American Railroads recognized that the key to the future national data processing system for the railroad industry was in the freight car ownership and number designation. In all existing systems in use up to this time, this specific information was always introduced manually, first by copying the car number with pencil and paper, then transcribing it to a typewritten list, and lastly, tranmitted via teletype to the various data handling centers, terminals, freight yards, and operating staffs. With the thousands of cars being moved daily, it was also apparent that many errors in the human handling of all these numbers resulted in considerable poor operating performance in the proper delivery and distribution of freight cars. To this end, then, a set of specifications were drawn up and were given wide-spread circulation to all interested manufacturers, research centers, and private consultants. Proposals for a practicable automatic car identification system were solicited in accordance with the following specifications.

A practical car identification system must operate within certain clearly defined physical limits. The tag on the freight car must not extend beyond the AAR standard car diagram. The scanner mounted on the side of the road must lie outside the standard AAR clearance diagram for wayside objects. These two diagrams taken together, then, fix the distance through which the device must operate. It can be readily seen that, in general, devices on the side of the car will be about 130 centimeters from the scanner. If the device is installed under the car, it will be located about 30 centimeters from the scanner.

Both the tag on the car and the scanner must be simple, rugged devices. The car tag must be unpowered and must operate with no moving parts nor require any maintenance, once it is installed. In addition, it must be inexpensive, easy to build, simple to attach, and it must be capable of being encoded in the field by inexperienced personnel.

The system must operate reliably throughout the speed range of 5 to 60 miles per hour. It must also be insensitive to direction of travel of the freight car. Further, the equipment must operate satisfactorily in all the climatic conditions encoutered in normal railroad service in North America. Extremes of temperature, sun, wind, rain, snow, ice, dirt, vibration, and shock can be expected in any railroad installation.

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The operating tolerances of the equipment must allow for the normal variation in height, side-sway, and inclination of the average freight car.

The equipment must be so arranged that it will detect and indicate the passage of an unmarked car. Also, if the number as read is suspect, for example, fails to pass a parity check, an appropriate mark will be inserted after the number to show that this number is possibly in error.

Lastly, the information processed by the scanner must be readily available in the normal 5- channel teletype code for transmission to a distant point or for use in operating a tape perforator or teletypewriter immediately from the scanner.

A technical committee of railroad engineers reviewed and analyzed these proposals, with the result that four systems are now undergoing evaluation on American railroads.

System A is offered by General Electric Company and uses radio frequency operating in the region of the lower end of the standard broadcast band. The car element is called the DEZIGNATOR unit by General Electric Company and is mounted underneath the car, attached to the track bolster. It consists of an antenna and several piezo electric elements each tuned to a specific antenna and is installed between the rails on the ties. A sweep oscillator drives the scanner antenna through the frequency range selected for this system. If no car is present, no signal is received by the receiving antenna. When the freight car moves within the field of the scanner, the sweep oscillator starts its sweep. At the instances when the sweep oscillator is at the resonant frequency of the piezo electric elements, a signal is picked up by the receiver. At the same time the scanning antenna is sweeping, a reference set of filters are also being swept. The signal from the reference filter group is compared with the presence or absence of a signal from the receiver. When identified frequencies respond to the sweep oscillator from both the reference filter group and the car device at exactly the same time, a binary "1" is produced. When no coincident pulse is received from the receiver, a binary "zero" is the result. The coding system is a four-bit code with the unusual feature that no more than two frequencies, or piezo electric elements, are required for each digit. The resonant frequency matrix is such that the frequencies are sweep in three parallel groups in order to decode all the digits in the proper length of time. Once the binary ones and zeros are obtained, the logic circuitry processes these signals for use with a teletype tape perforator.

System B proposed by American Brake Shoe Company depends on the ability to focus carefully, and at close range, a microwave region radio frequency beam. The scanner consists of a suitable power supply, a klystron tube, necessary wave guides, a transmitting horn, and a carefully designed antenna. The klystron operates at 35 Gigacycle and the wave length is of the order of one centimeter. The microwave beam is focused to strike the freight car in the region of the proposed location of the reflecting plaque. An unpolarized beam is transmitted by the scanner. The reflecting plate, on the other hand, consists of polarized dipoles of suitable length to reflect back the maximum radio frequency energy. The dipoles are polarized to insure adequate separation, on a signal strength basis, between spurious reflections from the car structure and the reflection from the spaced dipoles. The receiver consists of an antenna similar in construction to the transmitting antenna, a wave guide horn, and a simple crystal diode detector. The pulse train received from the plaque is clipped and shaped so that a series of square waves are produced. The first four dipoles establish a timing sequence. In this manner, the correct operation of the logic circuitry becomes independent of the freight car speed. A definite interval of time is established for each pulse. The presence of a pulse during that interval indicates a binary "1"; the absence of a pulse during the interval indicates a binary "0". The same initial four dipoles and blank spaces also serve to determine the direction of travel of the freight car relative to the receiver. Once the square wave pulse train is formed, each pulse—or absence of a pulse—is fed into a shift register for temporary storage. When the end of the coded number signal is received-determined by the order of bits in the last four positions—the shift register unloads in either the forward or backward direction to produce the correct array of binary bits representing the car number. A typical tag format will contain bits as follows: First four bits indicating "Start" of message, timing sequence, and direction of travel of the car. Next 12 bits to indicate railroad ownership by a three decimal digit number. Included within the plaque is a parity checking section wherein the total bit count of the car number portion is subtracted from an arbitrarily selected number, and this decimal digit difference is encoded in binary form within the message. If the bit count of the signal as received tallys with the encoded parity number, a command is then given to unload the last shift register and to transmit the information to a teletype circuit for operating a tape perforator. If the parity check is incorrect, a question mark is printed after the number. If a plaque is completely missing from the car, a row of symbols such as * are printed in place of the car number.

The logic circuitry of this system has been described at great length only to show how the received signal is processed into teletype code form. In all the systems under investigation, this function is essentially the same, differing primarily in such elements as parity checking, "start" and "stop" commands, timing sequence; therefore, in subsequent descriptions, we shall stop with the method of generating the pulse train.

System C is offered by Union Switch & Signal Division of Westinghouse Air Brake Company. The car is equipped with a tag on which is mounted a reflective sign coded to indicate the car numbers. The reflective material has an adhesive backing and is coded directly in the normal teletype code. In a typical computer word length, the binary 1's are designated by a wide strip of reflective material.

The binary zeros are indicated by narrow stripes. Stripes may be either white or black. The key to the operation lies in the fact that each stripe must alternate in color with the preceding one, so that a white stripe must be followed by black, and vice versa. Inasmuch as each decimal digit is represented by 5 bits of alternate white and black stripes, it may be readily seen that each decimal digit must exist in two color complementary forms. This alternation of color is necessary for proper operation and discrimination in the scanner photocells. The scanner emits a beam of light with considerable energy in the infra-red portion of the spectrum. The reflected energy, unhampered by fog, haze, snow, or rain, is focused by an optical system on an array of five photoconductive cells. These photocells are arranged as narrow, broad, narrow, broad and again narrow elements. The spacing is such that the image of a wide reflective stripe covers both broad cells. The image of a narrow stripe can only cover one of the broad cells. The two narrow end cells determine the presence of a label. Depending on which broad cell was activated first, the storage shift register will print out in either the forward or reverse direction. In this manner, between the change of state of the photocells, caused by the alternating black and white stripes, and the fact that both broad cells are energized for a binary one and only one broad cell is energized for binary zero, the binary signals so detected are fed into the logic portion of the equipment, checked for parity and also for total bit count, and are then made available for transmission on the communications network in a manner similar to that previously described for the first system.

System D is offered by Sylvania Electric Products, Inc. The basis of this system is an optical reflective arrangement utilizing a unique material manufactured by Minnesota Mining and Manufacturing Company. The labels attached to the cars are coated with a retro-refractive material which has the property of reflecting light directly back to the source, regardless of the angle of incidence, within reasonable limits. The labels themselves are furnished in various colors to conform to a color coded combination representing each number. Each portion of the label consists of two colors. The first two represent the "Start" signal and the last two represent the "Stop" signal. In between are arranged the various elements of the car ownership and number designation. The first portion of each label is colored blue, orange, or white. The second portion must be blue, orange, white, or black. The labels are affixed by the adhesive backing to the car side. Because of the nature of the scanner, great latitude is permitted in the location, alignment, height, and spacing of the individual elements of the label. The trackside scanner consists of a high intensity light source aimed at the flat mirrored surfaces of a rotating scanner wheel. In this manner, the beam of light is caused to scan the label from bottom to top. The reflected colored light strikes this same rotating mirror array and is transmitted through an unsilvered mirror and lens system and is focused through a dichroic mirror designed to reflect blue light and to transmit orange light. The split beams are aimed at photomultiplier tubes with suitable blue or orange filters placed just before the tubes for additional color discrimination. By this arrangement, four modes of detection are possible: from orange labels, an orange signal; from blue labels, a blue signal; from white labels, both blue and orange signals; from black labels, no signal. The signals produced by the photomultiplier tubes are passed to the logic circuitry and into the shift register. Subsequent action is essentially similar to the procedure described earlier.

To date, limited field testing has been conducted with the General Electric Company, Westinghouse Air Brake Company, and the Sylvania Electric Products Company systems. The systems have been subjected to typical railroad service wherein lading material has spilled and partially obliterated the labels. Mud, snow, and ice have accumulated on the cars around the labels. Temperature and weather extremes from summer to to winter have also been encountered. In all cases, such field testing has resulted in further modifications and refinements both in the construction of the label and also in the design of the scanner. In general, extremely g results have been obtained with the logic circuitry in all systems. Operat at prevailing train speeds has been good, and the information has be presented generally on a printer located at or near the scanner. In so cases, the information has been transmitted over a voice channel to printer or card puncher located at a remote installation. In this manner permanent record has been accumulated over the period of testing so t some degree of reliability could be measured. In the case of Westinghouse Brake Company, a reliability figure of 99.75% has been achieved. In case of Sylvania, it has been found that if only 1% of the label is visible can be read. Also vertical placement with a six-foot height can be accom dated as well as labels placed on the curved surfaces of tank cars. There a two-foot depth of field incorporated in the optical system. Long term liability testing is now under way on a group of 40 trains in each direct daily for this coming winter.

The General Electric Company system has been on test on a group of c passing the scanner location for about six months. In this installation, t numbers have been recorded on punched cards and a daily list has been f nished by the railroad of all the cars that actually passed the scanner. T two lists have then been checked on a sorting and matching program w the finding that a total of four errors have been recorded. Two errors ha been found due to malfunction of the receiving equipment associated w the antenna installation, and the other two incorrect numbers have be unaccountable thus far. This performance indicates an error rate on t order of 1 in 10,000 labels.

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However, the ultimate value of automatic car identification results fro a nationwide railroad data processing center that could serve the enti North American continent. In such a system, several preliminary steps a required. First, the communications plants of all affected railroads must be interconnected that there is, practically, one large network serving the ent railroad industry within the country. Secondly, a message routing a editing computer is required to which this communications network connected. A standardized message heading format must be develope which contains within itself instructions to the computer on messag routing, message editing, information abstracting, selective station calling and limited computational instructions. The third major effort must be [illegible] gigantic and often chaotic rate structure to an orderly, logica one than can be stored [illegible] computer memory [illegible] encoded [illegible] similarly [illegible] centage [illegible] revenue [illegible] moving a shipment [illegible] combination [illegible] also be stored in such [illegible] fourth element [illegible] an accurate electronic weighing [illegible] be installed [illegible] car number reader.

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However, the ultimate value of automatic car identification results from a nationwide railroad data processing center that could serve the entire North American continent. In such a system, several preliminary steps are required. First, the communications plants of all affected railroads must be so interconnected that there is, practically, one large network serving the entire railroad industry within the country. Secondly, a message routing and editing computer is required to which this communications network is connected. A standardized message heading format must be developed which contains within itself instructions to the computer on message routing, message editing, information abstracting, selective station calling, and limited computational instructions. The third major effort must be in reducing the gigantic and often chaotic rate structure to an orderly, logical one than can be stored in a large scale computer memory with all commodities encoded for ready reference; all stations similarly encoded. The percentage of division of revenue for moving a shipment over all practicable combinations of routes must also be stored in such a memory unit. The fourth element required is an accurate electronic weighing device that would be installed adjacent to a car number reader.

We may then see that the typical car number reader station will insert into its message, information as to the designation of the reporting station, the time and date, the train number, and then the list of car numbers and their weights. Therefore, at the time a shipment is originated, all the pertinent information concerning that shipper, consignee, destination, commodity, routing, special instructions, would be transmitted via the standarized message format to the central computer. At this time, the car number of the load would be assigned, together with the "waybill" number under which the car is moved. The message computer would extract portions of this message and notify stations in line of movement that a shipment is on the way. The various traffic departments would likewise be advised of such movement. The consignee would be notified and the railroad owning the freight car would receive advice that their car was in revenue service. The remainder of the message would go to the rate computer where the correct rate would be selected for the commodity, the weight would be obtained from the electronic weighing device, the division of revenue would be made and each railroad would be credited with their portion of the freight charges.

As the freight car moves across the country, the automatic car identification equipment will read the car number from the freight car and will correct the present location of the car in the appropriate section of the computer storage. The progress of the car and shipment will be instantaneously available to both the shipper or any railroad handling the movement. As soon as the car is delivered, demurrage and car rental charges are calculated daily and appropriate credits and debits recorded for each railroad. As soon as the car is released, it is available for movement in accordance with the car distribution and assignment plan developed by the computer in response to requests for cars from shippers. Settlement of all inter-line accounts would be carried out through a clearing house associated with this large computer and all revenues would be distributed according to the computer record.

The car rental charges would be computed on a daily basis and at the end of the month, net settlements would be made through the same clearing house, based on the computer record of car locations at the end of each working day.

Since the freight car inventory for the entire continent would be automatic, accurate, and current, it would follow that cars would be used to better advantage. There would be less probability of temporarily lost cars or cases of incorrect routing and distribution. If cars are used to a greater extent than at present, it also follows that there would be a reduction in the apparent car shortage and that better car utilization would result in freeing some of the money now required for capital expenditures to increase the fleet of freight cars. While the economic value of this proposition may be difficult to ascertain, a small 5% increase in utilization of 2,000,000 freight cars indicates that the pool of available cars has been increased by 100,000. Even if this number is reduced to only 10,000 effective freight cars, such an increase represents a capital savings of $100,000,000 by today's prices.

Not the least important consideration of adopting such a system in the highly competitive transportation field is the improved and accurate freight traffic information available to the shipper, the consignee, and the railroad freight traffic salesman. The ability to locate a shipment quickly and to inform the customer is of the utmost importance when rendering a service. The finding of an error in routing and the rapid correction of a mis-directed shipment will be the difference between a satisfied customer and shipment lost to other forms of transportation.